



## DEPARTMENT OF ENERGY

### Fusion Prototypic Neutron Source (FPNS)

**AGENCY:** Office of Science, Department of Energy.

**ACTION:** Request for information (RFI).

**SUMMARY:** The Office of Science in the Department of Energy (DOE) invites interested parties to provide input on potential technological approaches to meet the needs of the Fusion Energy Sciences (FES) program for a Fusion Prototypic Neutron Source (FPNS) and on potential ways to accelerate the construction and delivery of such a facility, including partnerships with the private sector.

**DATES:** Responses to the RFI must be received by **[INSERT DATE 45 DAYS AFTER DATE OF PUBLICATION IN THE *FEDERAL REGISTER*]**.

**ADDRESSES:** DOE is using the *www.regulations.gov* system for the submission and posting of public comments in this proceeding. All comments in response to this RFI are therefore to be submitted electronically through *www.regulations.gov*, via the web form accessed by following the “Submit a Formal Comment” link.

**FOR FURTHER INFORMATION CONTACT:** Questions may be submitted to *fpns@science.doe.gov* or to Daniel Clark at (240) 780-6529.

### SUPPLEMENTARY INFORMATION:

#### Background

The scientific and engineering demonstration of fusion energy will require mastering materials science and performance issues, particularly those associated with materials degradation due to bombardment by the energetic (14.1 MeV) deuterium-tritium (D-T) fusion neutrons. This performance degradation provides the basis for and is one of the single largest inherent limiting factors for the economic, safety, and environmental attractiveness of fusion energy. As such, the FES program places a high priority on

gaining an improved understanding of the science of materials degradation due to fusion neutron bombardment, particularly as it pertains to enabling the development of next-generation, high-performance materials for future fusion devices.

Managing this fusion neutron-induced property degradation is one of the most significant scientific “grand challenges” facing fusion energy development. Although considerable progress has been made exploring the resistance of fusion materials to neutron-based displacement damage with the use of tools available today, such as fission test reactors, ion beams, and computer simulation, the current knowledge base for bulk mechanical and physical property degradation in a realistic fusion environment with simultaneous transmutation effects is limited. The requirement to understand 14.1 MeV neutron-induced material degradation underscores the critical need for a Fusion Prototypic Neutron Source (FPNS), which is aimed at enabling investigation of the effects of fusion-relevant irradiation on both microstructural evolution and bulk material properties degradation.

An FPNS will address the fundamental question of whether materials retain adequate properties for damage levels greater than 20–50 displacements per atom (dpa) in a fusion neutron environment, and lifetime limits from an engineering science perspective at higher levels of irradiation. This will enable the generation of engineering data that is required to design and deploy commercial fusion devices. These roles could be addressed in either the same or complementary irradiation facilities.

The 2020 Long-Range Plan (LRP)<sup>1</sup> “Powering the Future: Fusion & Plasmas” developed by the Fusion Energy Sciences Advisory Committee (FESAC), included strong support

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<sup>1</sup>[https://science.osti.gov/-/media/fes/fesac/pdf/2020/202012/FESAC\\_Report\\_2020\\_Powering\\_the\\_Future.pdf](https://science.osti.gov/-/media/fes/fesac/pdf/2020/202012/FESAC_Report_2020_Powering_the_Future.pdf)

for an FPNS, which was viewed as not only filling a key gap in the science mission of FES but as an opportunity to provide world leadership by enabling the fundamental explorations of fusion nuclear material science. Among the key recommendations of the LRP was to “Immediately establish the mission need for an FPNS facility to support development of new materials suitable for use in the fusion nuclear environment and pursue design and construction as soon as possible.”

In addition, the 2021 National Academies of Sciences, Engineering, and Medicine (NASEM) report, *Bringing Fusion to the U.S. Grid*,<sup>2</sup> emphasized the need for materials research and a neutron irradiation capability to enable a Fusion Pilot Plant (FPP), including facilities to provide a limited-volume prototypic neutron source for testing of advanced structural and functional materials and to assess neutron-degradation limits of Reduced Activation Ferritic Martensitic (RAFM) alloys beyond 5 MW-year m<sup>-2</sup>.

In 2022, the Electric Power Research Institute (EPRI) sponsored an FPNS workshop<sup>3</sup> at which a strong consensus was reached in support of an FPNS delivered in 2028 or earlier, that would meet the requirements provided in Table 1, and that FPNS be designed with sufficient capability for future upgrade(s) to deliver increased performance capability by 2032, or earlier, also as shown in Table 1. There remained a strong consensus that the FPNS neutron spectrum must introduce appropriate levels of gaseous and solid transmutant impurities into the tested materials, consistent with the fusion neutron environment.

Parameter	Capability Requirement by 2028 or earlier	Capability Requirement by 2032 or earlier
Damage rate	5 to 11 dpa/calendar year (Fe equivalent)	15 dpa/calendar year (Fe equivalent)

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<sup>2</sup> <https://nap.nationalacademies.org/catalog/25991/bringing-fusion-to-the-us-grid>.

<sup>3</sup> <https://www.epri.com/research/products/000000003002023917>.

Spectrum	Gaseous and solid transmutant generation rates consistent with 14 MeV fusion neutron	Gaseous and solid transmutant generation rates consistent with 14 MeV fusion neutron
Sample volume in high flux zone	$\geq 50 \text{ cm}^3$	$\geq 300 \text{ cm}^3$
Temperature range	$\sim 300$ to $1200^\circ\text{C}$	$\sim 300$ to $1200^\circ\text{C}$
Temperature control	3 independently monitored and controlled regions	4 independently monitored and controlled regions
Flux gradient	$\leq 20\%/ \text{cm}$ in the plane of the sample	$\leq 20\%/ \text{cm}$ in the plane of the sample

**Table 1.** *FPNS performance requirements desired by 2028 or earlier, and 2032 or earlier, as indicated in Columns 2 and 3, respectively.*

To meet the mission of the Bold Decadal Vision for Commercial Fusion Energy,<sup>4</sup> the design and demonstration of an FPP must occur simultaneously with the design and construction of the FPNS. Thus, the results from an FPNS may not directly impact the design and construction of the first FPP but will be critical to later iterations of FPP and eventual licensing of commercial fusion power plants.

### Questions for Input

SC is issuing this Request for Information on potential technological approaches to meet the needs listed in Table 1, and on potential ways to accelerate the construction and delivery of an FPNS including public-private partnerships. Of special interest are approaches leading to a facility under a total capital cost of \$500M, even if meeting this objective would require upfront R&D. Responses should include discussions of the following topics (limit all responses to five pages):

- Technological approach to meeting the performance requirements in Table 1 (provide the parameters listed in Table 1 that would be achieved based on projections of your proposed approach);
- Technical maturity and risks of the concept;

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<sup>4</sup> <https://www.whitehouse.gov/ostp/news-updates/2022/03/15/fact-sheet-developing-a-bold-vision-for-commercial-fusion-energy/>.

- Research and development required (with rough cost/schedule and go/no-go milestones) to increase the technical readiness level and retire risks such that a final design can be completed;
- Estimated capital and operating costs;
- Potential for performing accelerated irradiation studies;
- Similarity or deviation of neutron irradiation spectrum relative to prototypic fusion device conditions (be quantitative);
- Temperature and irradiation flux stability/control;
- Ability to perform multiple-effect tests (*e.g.*, irradiation in the presence of a flowing coolant or in the presence of complex applied stress fields); and
- Potential commercial partners, markets, and opportunities for public-private partnerships in funding and constructing FPNS.

### **Signing Authority**

This document of the Department of Energy was signed on March 20, 2023, by Asmeret Asefaw Berhe, Director, Office of Science, pursuant to delegated authority from the Secretary of Energy. The document with the original signature and date is maintained by DOE. For administrative purposes only, and in compliance with requirements of the Office of the Federal Register, the undersigned DOE Federal Register Liaison Officer has been authorized to sign and submit the document in electronic format for publication, as an official document of the Department of Energy. This administrative process in no way alters the legal effect of this document upon publication in the *Federal Register*.

Signed in Washington, DC, on March 21, 2023.

**Treena V. Garrett,**  
*Federal Register Liaison Officer,*

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